



## **Process Competences in PBL**

### Qualitative Assessment of an Experience

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## **Process Competences in PBL**

### **Qualitative Assessment of an Experience**

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## **INTRODUCTION**

Constraining calendars and highly specialised curricular requirements make most teachers on engineering and related technical education focus mainly on fulfilling the technical requirements and objectives described in the curricula for their courses. Other fundamental aspects of the daily work of an engineer, in our current globalised and heterogeneous reality, are therefore not properly considered, when not completely disregarded, when designing course and curricular objectives. From this perspective, more professional skills like group formation, analysis and characterisation, group work methodologies, meetings, communication and discussions, coordination, delegation, analysis and self-critic of the group performance are not usually tackled. The result is a disadvantage for newly graduated students, when they have to enter in a highly competitive job market, where efficiency and quality of their output are the main reference elements for their evaluation.

This article presents an experience in which some of these elements have been introduced in an existing course, tailored as a Problem Base Learning (PBL) course in Advanced Telecommunication at the Technical University of Denmark (DTU). The results have been evaluated and assessed by the students, in the light of their own personal experiences and evolution during the course.

## **1 THEORETICAL BACKGROUND AND STATE OF THE ART**

In the discussions about the contemporary development of Engineering Education there is an increased focus on that students during their education would benefit if professional skills were included in the curriculum and used as a motivator to create incentive in studying the disciplinary knowledge. The reasons for this argument are several. One of the central arguments is that engineers are facing complex and interdisciplinary problems in a global arena. Being able to navigate in an intercultural and complex context demands professional competences and capabilities. For engineering students it is crucial to be given an opportunity to understand their roles as engineers in this kind of context and be trained to act in its complexity already during their education [1]. Another reason for including the training of professional skills in Engineering Education is that it also can serve as a driver for learning when it becomes clearer for the students how and in where to use the disciplinary knowledge and which problems and task in reality that can be solved. To let the students work with real life scenarios, preferably as close to reality as possible, have shown being an important driver for incentive and motivation in education [2]. Learning is a complex process and is linked to the context in which the learning is taking place. This is another important argument to explicitly address and train professional skills in education and courses, linked to the disciplinary knowledge. If a learning context can be formed where the learning of disciplinary knowledge and professional skills are enhancing each other, it is a powerful learning situation. This situation creates opportunities for students to gain a deeper understanding in the subject, to train them to act as professionals using the right skills and facilitate the ability to transfer the disciplinary knowledge into the practical situations where it is to be used [3]. The CDIO initiative is one attempt to systematically use those principles as a frame for structure Engineering Education [4].

Problem Based Learning (PBL) is a learning method that imbeds many of the traits in education that can facilitate both training of professional skills and disciplinary knowledge [5]. PBL is building on the idea of experiential learning which gives the students opportunity to use a broader range of thinking and acting skills while learning which due to many theories about learning ensure a stronger conceptual learning and also provide a learning context to train professional skills [6].

## **2 ADVANCED TELECOMMUNICATION – AS A PBL COURSE**

The DTU's course 34357 - Advanced Telecommunication was created in 2005, as a non traditional course, where students should work in groups, as independent professional teams, to solve a number of short tasks, organised as projects. The course is planned for last year students in the MSc of Telecommunication Engineering degree and is organised as a "role-game" where students have the role of consultants, attending the request of a company willing to implement new telecommunication services.

The course responsible has different roles in the course: representative of the requesting company and external expert consultant. From the perspective of the first role, the course responsible attends the students on issues regarding the customer objectives and desires, while from the perspective of the external expert, the course responsible provides guidance on knowledge or better: initiators or sources of knowledge.

The course is 13 week long, which is the duration of a full semester at DTU. The initial task is presented in week 2 with delivery deadline on week 4. An evaluation of the solution on the same task and authored by another team is requested on week 4

with deadline on week 5. A new task is assigned on week 5 with delivery deadline on week 7. In week 8 the last group-task is disclosed with deadline on week 11. In week 11 a new task is assigned, this time individual and as a self reflection exercise on the group work in the previous weeks.

The tasks are designed to be different and of increasing difficulty, ranging initially from very clear assignments, based on analysis of laboratory setups, and design of solutions based on these experiences to more conceptually abstract design and specification assignments, based on customer specifications and standard / normative documentation.

The course fits already from its origin with most of PBL principles [7]:

- Problem Orientation: The base for the learning process are a set of problems presented to the students within an emulated real environment.
- Project Organisation: The problems are presented to the students as a set of successive and related small tasks, which the students need to solve as projects.
- Integration of Theory and Practice: The course combine both theoretical sessions together with lab & practical sessions, in order to provide a realistic framework for the students to be able to work within their projects.
- Participant Direction: Students are fully responsible for defining the areas of concern within the project work, as well as for the methodology to follow to complete them.
- Team-based Approach: 3 out of 4 of the requested project-tasks in the course are based on group work. Usually in groups of 4-5 students.
- Collaboration and Feedback: the course responsible behaves as a coacher – facilitator, rather than a teacher or instructor. This facilitation focuses on student self reflection (as keystone for learning [6]) and critical thinking [8]).

## **2.1 Process Competences as a new aim**

The course had been designed initially with a bare technical focus, focusing mainly on a “Product” perspective: the technical contents (syllabus) of the course and the outcome of students in relation to it. After successive editions of the course it was evident for the responsible that, students could greatly benefit from an additional “Process” perspective to the course, which despite being inherent to PBL methodology [5][9], was not being tackled.

Therefore elements such as *Self Management*, *Self Evaluation*, *Cooperation*, *Communication*, *Learning to Learn* and *Independent Work* were considered, with the aim of fostering the “professional” behaviour of students and enable them to perform in an homogeneous way. As a result the focus of the practical experiment, described herein, was set to implementation of elements targeting these “Process Competences” within the course, and to measure their impact on student behaviour as well as on their “product”-outcome as described in the following section.

## **3 RESEARCH PROCESS**

### **3.1 Research Questions**

As mentioned earlier, the focus of this experiment was to introduce process-competences elements in the course and to measure their impact in student

performance. Simultaneously, it was interesting also to adapt the facilitation to the specific characteristics of each group.

Therefore the initial working hypotheses to proof were the following:

**H1.** Composing groups of complementary teams, based on personal differences, results in increased awareness of personal competencies and self-understanding, which in turn has a positive impact in the overall group dynamics.

**H2.** Providing a framework methodology for group-work

**a.** is an additional stress factor for students at the beginning of the course.

**b.** improves group results in the long term, both to the process and the product aspects of their work.

**H3.** Aligning facilitation work with group and individual characteristics improves student's confidence and foster their dedication to the group work.

### **3.2 Methods in the course and framing of the students' learning experience**

In order to target the presented hypothesis, a framework for students to understand group processes, from the perspective of effective working teams and its process competences was prepared.

Based on that, and as part of the "Forming" stage of their group formation, [10], each participant in the course had to analyze his own personal profile, from a professional characteristic point of view, i.e. Belbin roles [11] and from the perspective of preferred learning styles [12]. Based on this analysis, the group should provide, a strengths and weaknesses analysis of the group, as a part of a "Collaboration Agreement", in which the group should present the common shared goals and the cooperation mechanisms, rules and tools they would use along the course duration. This had to be done by students during the first 2 weeks of the course, before the initial task was presented.

The results of this initial characterization of the teams and its members would allow an alignment of the facilitation of each group with its specific profiles and needs, adjusting the "process" facilitation with the framework set in each of the groups specific "collaboration agreements" [13] and to target hypothesis 3.

Preparation of this framework, designing it and aligning it with the targets in mind was a quite extensive process in order to prepare the presented new process competences strategy and as well as the material it based on, together with the necessary modifications to the course, in relation to it. The most significant also was the addition of a Process Competences aspect in the evaluation of the teams. This "process aspect" of the course was significantly included as part of the evaluation, and as such included also as an element of the requirements to complement the product – outcome of the groups work: For each report / task the group should provide a description of the processes to achieve the end outcome / product, in terms of group communication, task planning and delegation, cooperation, conflicts, mood, etc all in a professional way including meeting agendas and meeting minutes. Furthermore, besides this, group members should provide an individual description of their work, from a product as well as from a process point of view, with self reflection on the learning outcomes and their own individual performance. This was to align their work and results with the theory on learning i.e. Kolb's self-reflection as keystone for learning [6]. Furthermore each team member should provide an evaluation of the other members of the team with the same aspects (product &

process) as consideration, following the suggestion at [14] in order to increase the performance.

From a product perspective, the tasks were prepared to create a simulated real environment with focus on high performance teams and self management within an engineering and learning environment. Based on Kolb's learning theory [6], students were induced to self-reflection, on their experiences as a necessary step assuring their learning progress.

The design of tasks was based on Hackmann & Oldham theory [15] regarding tasks and performance. According to it, tasks clear and meaningful, involving different competences, where the responsible has high degrees of autonomy, together with the appropriate levels of feedback on performance, have a positive impact in the psychological condition of the subject, resulting in high levels of motivation and quality. This needs to be simultaneously supported by a convenient framework that stimulates, challenges and rewards the individual.

Finally, the behaviour of the teacher and the corresponding facilitation to students was based on a model of situational behaviour [16]. The focus of the teacher was to concentrate on enabling the transition from a Support towards a Delegation model. That is, the assumption was on students having a certain level of technical competence but needing a boost on engagement, motivation and self confidence.

### **3.3 Execution of the investigation**

In order to test the impact of the described methodology on the results of the students and in order to test the initial hypotheses, a questionnaire was designed to test the different hypothesis.

In that questionnaire, questions 1-3 target Hypothesis 1:

1. To what extend are you aware of your Belbin-roles/Learning Style profile?
2. To what extend are you aware of your group's members Belbin-roles /Learning Style profiles?
3. Explain how and why the impact on your own work and the work of your team of this knowledge (about yourself and your team) is it positive, null or negative?

While questions 4 -6 target hypothesis 2:

4. Please comment on your feelings and opinion about the requirements on group work methodology (agendas, minutes, meeting roles, etc), i.e. are they an stress factor?
5. What is the impact of these requirements on your own work?
6. What is the impact of these requirements on the work of your team?

And questions 7–12 target hypothesis 3:

7. Regarding the received facilitation is it mainly Process oriented, mainly Product oriented or balanced: Product and Process oriented?
8. To what extend do you feel your group is responsible for the choices / solutions proposed?
9. Does the interaction with the group responsible help you to analyse – attack problems properly? Yes/No. Please explain.
10. After your work in the course, how is your “professional behavior” as a member of an engineering team increased? Please explain your answer.

11. How does the interaction with the course responsible impact your work? Please explain.
12. Considering your dedication to the group's work, how has it improved since the group formation?

Regarding this questionnaire, the following elements deserve a clarification: due to the reduced amount of participants (14) the questionnaire was built to gather qualitative results, since quantitative results would be no conclusive from an statistical perspective. Also, in the questionnaire, the available options for likely answers are heterogeneous, since they accommodate to the question they belong to in the questionnaire. Nevertheless the qualitative underlying semantic for most of them is equivalent, and the available options can be therefore interpreted as: Very Positive / Very Much, Positive / Much, Normal / Acceptable, Negative / Little, Very Negative / Very Little. Since these questions are supported with the possibility of clarifying the answer with further details, the impact of this heterogeneity and the likely misleading effect on the answers was disregarded.

The questionnaire was presented to the students in 2 different periods: in week 4 (out of 13) after their first project-task, which was the first group experience, and in week 11, after the 3<sup>rd</sup> and last of the group experiences. The questionnaire was the same in both cases and the reason for this duplication was to cope with the possibility of evolution of answers from students during the history of the collaboration. Besides this duplicated questionnaire, the students received the general course evaluation, common for all courses at DTU, at the end of the semester.

### **3.4 Analysis of results**

The first time the questionnaire was answered by students, after the first task-project, it was evident that, regarding hypothesis 1, the teams had used their own internal previous characterisation (personal and as a group) to distribute possible tasks according to their individual profiles or to overcome specific personal learning difficulties, but they were not in general aware of their peculiar characteristics nor considered them in discussions or work meetings. A group used it, on the other hand, to strengthen their weakest sides. Regarding hypothesis 2, students were, at an individual level, rather annoyed by all the requirements in order to formalise and document their work (meeting agendas, minutes, communication diagrams, tasks and delegation responsible). Despite the mentioned individual annoyance, they considered the impact on their group work as *relatively* positive. Regarding hypothesis 3, on facilitation, students are very surprised with the methodology followed. The teacher never provided a direct answer, but tried to guide the students with in-depth questions on the different issues, trying to foster their reflection processes on the subjects in order to gain self-esteem or referring them to alternative sources of knowledge. They felt it was balanced between Product and Process focuses. The students also felt they were responsible for their project objectives and solutions and this was also evident in their felt commitment to the group work.

The questionnaire was answered by students again at the end of their third task-project. By then the evolution of student awareness on their personal differences and their impact, is more evident. Students by that time had already started to appreciate the usefulness of documenting their discussions and their working processes. Regarding facilitation, students point out that this is more Product oriented, and this may be related also to their maturing as groups and the automation of their working processes, without external help or contributions. Regarding the level of freedom and responsibility over their work, the results are less positive than in the initial

questionnaire and this may be related to the character of the later tasks, which had grown in abstraction level. This required them to be much more sure of their technical knowledge to attack the tasks properly and in that sense they may have felt their “creativity” possibilities reduced. At that time students are very aware of their “professional behaviour” development and found it very positive.

The qualitative self evaluation of the teams requested for each of the tasks show also that, by the end of that period, the different groups are working as cohesive teams, without much effort spent in task delegation and coordination efforts. Whether this is related in part to the facilitation received can not be assured.

#### **4 CONCLUSIONS**

The results obtained from the questionnaires provided an initial validation to the presented hypotheses, although they can not be fully accepted due to the reduced number of students participating in this single experience (14 students) and their answers to the questionnaires. Students’ self-knowledge and awareness as members of a team, structured in a explicit and conscious way, seem to increase their understanding of the group capabilities and how to attack specific tasks in a more efficient way, as initially questioned by Hypothesis 1. Regarding Hypothesis 2, it is evident that the requirements to formalize their work based on a specific “process” methodology using agendas, meeting minutes, etc, was a burden for students. But its negative aspect was neutralized at the end of the course and some of the students appreciated them as valuable tools for the group.

Finally, the results of the course, and the students satisfaction with it, together with reflection on and their own performance, seem to validate also Hypothesis 3, although it is not demonstrated in any way that this is due to the facilitation received by the students. It seems like PBL can be a useful tool in teaching and learning to include training of professional skills. This investigation indicated that the professional skills must be addressed explicit and framed consciously by the teacher in the course. The students must also been given tools to use in order to understand how to work in a more professional and efficient way both individually and as a team.

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